



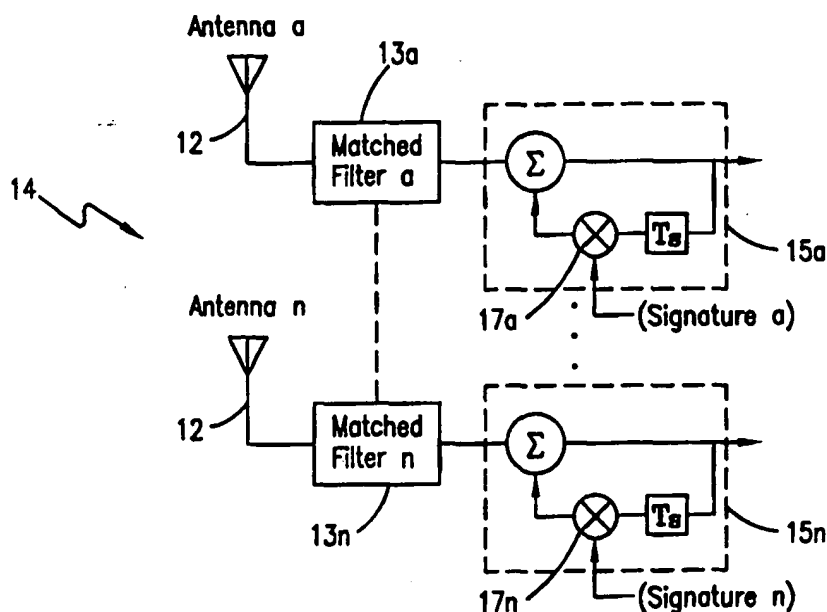
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : H04Q 7/38, 7/30, 7/32	A2	(11) International Publication Number: WO 98/18280
		(43) International Publication Date: 30 April 1998 (30.04.98)
(21) International Application Number: PCT/SE97/01722		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).
(22) International Filing Date: 14 October 1997 (14.10.97)		
(30) Priority Data: 08/733,501 18 October 1996 (18.10.96) US		
(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).		
(72) Inventor: ESMAILZADEH, Riaz; c/o Agren/Nilsson, Odennatan 44, 4tr, S-113 51 Stockholm (SE).		
(74) Agent: TELEFONAKTIEBOLAGET LM ERICSSON (publ); Patent and Trademark Dept., S-126 25 Stockholm (SE).		
		Published Without international search report and to be republished upon receipt of that report.

(54) Title: RANDOM ACCESS IN A MOBILE TELECOMMUNICATIONS SYSTEM

## (57) Abstract

A mobile communications system (10) is provided for significantly reducing the time required to process a random access mobile-originated call. During call setup, a mobile station (16, 18) transmits a random access packet that includes a preamble and a plurality of fields. The information provided in these fields is used by the base station (12) to facilitate a more efficient call setup and more quickly allocate channel resources. A system is also provided for detecting, identifying and receiving multiple random access requests. Each mobile station (16, 18) transmits one of a plurality of different preamble symbol patterns in a random access request packet. The base station receiver (14) includes a plurality of accumulators (126), each of which is tuned to a different preamble symbol pattern. Consequently, the base station receiver (14) can distinguish between simultaneous random access requests. This preamble symbol arrangement can also be used in conjunction with power-ramping processes, such as those used in IS-95 and CODIT systems, to provide individual power control for mobile stations making multiple random access attempts.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

## RANDOM ACCESS IN A MOBILE TELECOMMUNICATIONS SYSTEM

### BACKGROUND OF THE INVENTION

5           Technical Field of the Invention

The present invention relates generally to the field of mobile telecommunications and, in particular, to a system for processing multiple random access mobile-originated calls.

10           Description of Related Art

The next generation of mobile communications systems will be required to provide a broad selection of telecommunications services including digital voice, video and data in packet and channel-switched modes. As a result, the number of calls being made is expected to increase significantly, which will result in much higher traffic density on random access channels (RACHs). Unfortunately, this higher traffic density will also result in increased collisions and access failures. Consequently, the new generation of mobile communications systems will have to use much faster random access procedures, in order to increase their access success rates and reduce their access request processing times.

In most mobile communications systems, such as, for example, the European joint development referred to as the "Code Division Testbed" (CODIT), and systems operating in accordance with the IS-95 Standard (ANSI J-STD-008), a mobile station can gain access to a base station by first determining that the RACH is available for use. Then, the mobile station transmits a series of access request preambles (e.g., single 127 chip symbols) with increasing power levels, until the base station detects the access request. In response, the base station starts the process of controlling the mobile station's transmitted power via a downlink channel. Once the initial "handshaking" between the mobile station and base station has been completed, the mobile user transmits a random access message.

More specifically, in a CODIT-based Code Division Multiple Access (CDMA) system, a mobile station will attempt to access the base station receiver by using a "power ramping" process that increases the power level of each successive

- 2 -

transmitted preamble symbol. As soon as an access request preamble is detected, the base station activates a closed loop power control circuit, which functions to control the mobile station's transmitted power level in order to keep the received signal power from the mobile station at a desired level. The mobile station then  
5 transmits its specific access request data. The base station's receiver "despreads" the received (spread spectrum) signals using a matched filter, and diversity-combines the despread signals to take advantage of channel multipath diversity.

In an IS-95 CDMA system, a similar random access technique is used. However, the primary difference between the CODIT and IS-95 process is that the  
10 IS-95 mobile station transmits a complete random access packet. If the base station does not acknowledge the access request, the IS-95 mobile station re-transmits the access request packet at a higher power level. This process continues until the base station acknowledges the access request.

In the Spread Spectrum Slot Reservation Multiple Access (SS-SRMA)  
15 System, a slotted ALOHA random access scheme is used. Generally, a mobile station transmits and re-transmits the random access packet until the correct reception of the random access packet is acknowledged by the base station. The transmissions are spaced apart by random time intervals. However, the slotted ALOHA random access process is inherently unstable. Consequently, some form  
20 of feedback loop must be implemented to stabilize such a system. Furthermore, no provision is made to distinguish between multiple signal arrivals, which results in an increasing number of collisions and, necessarily, re-transmissions, and thus worsens the instability problem.

A number of significant problems exist with the above-described random  
25 access techniques. For example, in a CODIT system, a base station receiver can detect only one random access at a time. If two mobile stations transmit their access requests at the same time, either the two messages will collide and be destroyed, or one message will be recognized and the other ignored. Consequently, the throughput efficiency of such a system is relatively low, its collision ratio is high,  
30 and the mean time that it takes to achieve a successful access is excessively long. A system that would resolve collisions problems and effectively process multiple

- 3 -

random requests is desirable, but to increase the throughput of the existing systems would require an increase in the number of access codes used (which are typically limited in number), and a corresponding number of additional matched filters would be required at the base station receiver.

5           Although existing IS-95 and SS-SRMA documents indicate that their base station CDMA receivers can demodulate multiple random access messages arriving in the same slot, these documents do not specify how this process can be implemented. Furthermore, the IS-95 documents do not indicate how to control the transmission power of the individual multiple access signals.

10           Additionally, the above-described IS-95 and CODIT random access processes are relatively slow, because numerous power ramping increments have to occur until an access request can be detected and acknowledged, and re-transmissions in the SS-SRMA system cause intolerable delays. Also, it is a relatively difficult process to implement a system that can receive multiple random access requests and control the  
15           power level of each individual request message. Consequently, for all of the above-described reasons, the usage efficiencies of the CODIT, IS-95 and SS-SRMA RACHs are very low, and traffic interference experienced by users of these systems is excessive due to this inefficient use of the RACH and the numerous re-transmissions required.

20           Yet another problem with these CDMA systems is that they are basically not designed to resolve packet collision problems. Consequently, the throughput of these systems is further reduced because of numerous failed random access attempts and further related inefficiencies.

## 25           SUMMARY OF THE INVENTION

          A mobile communications system is provided for significantly reducing the time required to process a random access mobile-originated call. During call setup, a mobile station transmits a random access packet that includes a preamble and a plurality of fields. The information provided in these fields is used by the base  
30           station to facilitate a more efficient call setup and more quickly allocate channel resources.

- 4 -

A mobile communications system is also provided for detecting, identifying and receiving multiple random access requests. Each mobile station transmits one of a plurality of different preamble symbol patterns in a random access request packet. The base station receiver includes a plurality of accumulators, each of which is tuned to a different preamble symbol pattern. Consequently, the base station receiver can distinguish between and process simultaneous random access requests. This preamble symbol arrangement can also be used in conjunction with power-ramping processes, such as those used in IS-95 and CODIT systems, to provide individual power control for mobile stations making multiple random access attempts.

#### BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a diagram that illustrates an access request data frame, in accordance with a preferred embodiment of the present invention;

FIGURE 2 is a schematic block diagram of a cellular communications system;

FIGURE 3 is a schematic block diagram that illustrates a pertinent section of a base station random access receiver, in accordance with the preferred embodiment of the present invention;

FIGURE 4 is a schematic block diagram that illustrates a receiver that can be used to implement a method of demodulating multiple random access requests and also providing power control processing for each request, in accordance with a second embodiment of the present invention; FIGURE 5 is a diagram that shows eight exemplary signature patterns that can be used as random access request preambles by a plurality of mobile stations;

FIGURE 6 is a schematic block diagram that illustrates how multiple random access requests can be correctly received and demodulated, in accordance with another embodiment of the present invention; and

- 5 -

FIGURE 7 is a schematic block diagram of the details of the base station receiver shown in FIGURE 6.

#### DETAILED DESCRIPTION OF THE DRAWINGS

5           The preferred embodiment of the present invention and its advantages are best understood by referring to FIGURES 1-7 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

Essentially, during the access request phase of a mobile-originated call, the mobile station that is preparing to request access to the base station receiver  
10           generates an access request data frame to be transmitted. A diagram that illustrates such an access request data frame is shown in FIGURE 1. For the preferred embodiment of the present invention, the access request data frame is composed of a preamble, and forward-error-correction (FEC) coded information about the mobile station's identity, the type of service required, the air-time required, "short" data,  
15           and error detection symbols. Each access request frame is typically 10 msec long. Alternatively, a shorter frame length may be used (e.g., 5 msec long). The access request frame described herein can be referred to broadly as a "facilitating" random access request frame.

Prior to generating the access request data frame, it is assumed that the  
20           mobile station has already obtained frame synchronization information from the base station's broadcast channel (BCH), as well as estimating shadowing and distance attenuation with respect to the transmission channel (the transmission path between the mobile and base stations). Taking into account this information, the mobile station transmits the access request data packet at the beginning of the next random  
25           access frame, and with an adequate power level to compensate for shadowing and distance attenuation. At the intended base station, the access request frame is demodulated utilizing a matched filter-based receiver. If the access request frame is properly received and demodulated, the base station acknowledges the request and schedules accordingly to process the mobile station's subsequent information  
30           transmissions.

- 6 -

Specifically, referring to FIGURE 2, a pertinent section of a cellular communications system 10 is shown, which includes a base station transmit/receive antenna 12 and transmitter/receiver section 14, and a plurality of mobile stations 16 and 18. Although only two mobile stations are shown, FIGURE 2 is for illustrative purposes and the present invention can be assumed to include more than two mobile stations. Prior to generating and transmitting an access request frame, a mobile station (e.g., 16) acquires synchronization, or synchronizes, with an intended base station receiver (14). The mobile station then determines the starting time for each random access frame, from the base station's broadcast/pilot channel information. If the base station is configured to measure and broadcast the total amount of traffic present at its receiver (e.g., representing multi-user interference), the mobile station receives and detects this information and uses it to calculate a signal transmission level that is needed to overcome the interference. By measuring the level and rate of change of the received broadcast/pilot signals, the mobile station estimates the Doppler fading rate and number of significant "rays" existing in the transmission channel. The mobile station then estimates the shadowing and distance attenuation of the transmission channel, by measuring the path loss over a sufficient number of fading periods. Taking into account the degree of transmission diversity required by the system, the mobile station then calculates the transmission power level required for the access request frame to be received at the base station, with a predetermined signal-to-interference ratio.

Referring again to FIGURE 1, the access request frame shown includes a preamble of L unmodulated symbols. Preferably, for this embodiment, each symbol is 1023 chips long. The spreading ratio of the preamble is selected to be longer than the spreading ratio of the rest of the frame, in order to have a better spreading gain and also to reduce uncertainty at the base station. Due to different users' propagation delays, and because the base station has to receive the first symbol within a pre-defined window, the preamble symbols are chosen to be longer than the system's maximum propagation delay. The preamble can contain a unique signature pattern, which will be described in detail below.



- 7 -

The access request frame also includes a user identity (ID) field of length N symbols. The mobile station randomly selects the symbols that make up the ID field. The use of a longer user ID will decrease the probability that simultaneous random access requests from two mobile stations (e.g., 16 and 18) will include the same random ID. However, using a longer identity field will also increase the overall frame length, which in turn, can increase the frame error rate (FER) probability. So, the length of the ID field should be selected with this characteristic in mind.

Another field in the access request frame is the required service number (K). The length of the required service number is determined by the number of possible services that are to be provided by the system. A short data message Q symbols long may also be transmitted in the random access request packet to increase the transmission efficiency. For example, a short data message transmission can obviate the need to complete the normal call setup process and reduce the other overhead messages required, since there is a very limited amount of data to be transmitted.

A required air time field of M symbols is also included in the random access request frame. For this embodiment, "required air time" is defined as the total time the mobile station will need in order to transmit a complete message. The level of detail to be included in this field is a design preference, which depends primarily on the extent that the FER will be affected. An error detection redundancy field (cyclic redundancy code of P symbols long) is also included as a design preference, which depends on the overall frame length desired. Except for the preamble, the information included in the random access request frame is forward error correction (FEC) coded using a known coding technique. Although the embodiment shown in FIGURE 1 includes specific information in each FEC coded field, the invention is not intended to be so limited in scope. For example, any information that can be used by a base station receiver to more quickly and efficiently set up a random access call can be included as a field in the frame structure shown. Also, the information included in these fields does not have to be FEC coded in order to be covered by the present inventive concept.

- 8 -

The random access request frame shown in FIGURE 1 is preferably transmitted at the beginning of the next slot. The mobile station (16) sets the transmission power level for this packet at a level appropriate to compensate for shadowing and distance transmission channel attenuation. For this embodiment, the  
5 Rayleigh fading factor can be assumed to be largely compensated for by employing diversity reception and combining techniques at the base station receiver 14.

FIGURE 3 is a schematic block diagram that illustrates a pertinent section of a base station random access receiver 14, in accordance with the preferred embodiment of the present invention. As shown in FIGURE 3, the front end of the  
10 base station receiver 10 includes a plurality of antennas 12a-n. The output of each antenna is coupled to a respective matched filter 13a-n. The output of each matched filter is coupled to a respective accumulator 15a-n. The output of each accumulator 15a-n is coupled to a respective peak signal detector (not explicitly shown). A more complete receiver section will be described in detail below.

15 In operation, each matched filter 13a-n is tuned initially to the base station's specific preamble spreading code. The output of each matched filter is recursively accumulated over the symbol period,  $T_s$ , for the duration of L preamble symbols. If the preamble includes a signature pattern (described below), the accumulation is accomplished by using a bank of accumulators, with each accumulator tuned to one  
20 of the signature patterns. The type of recursive accumulation technique used may be either coherent or incoherent accumulation, depending on the transmission channel's fading rate. Preferably, coherent accumulation is used because it is more beneficial for CDMA demodulation and can be used even at moderately high fading rates.

25 At the end of the preamble period, each accumulator 15a-n in the base station receiver section 14 searches the output of the respective matched filter 13a-n for each signal peak that exceeds a predetermined detection threshold. Each accumulator then registers (detects and stores) the magnitude and relative phase of each of those peak signals, and thereby determines the number of significant signal  
30 rays available for demodulation in the receiver. A rake receiver section (not explicitly shown) demodulates the data portion of the random access request frame,

- 9 -

by using one of a selection, equal gain, or maximal ratio combining demodulation schemes. For one embodiment, a selection combining demodulation scheme is preferred, because it facilitates multiple random access reception (discussed below). For another embodiment, an equal gain or maximal ratio combining demodulation  
5 scheme may be used when an identification of each individual access attempt is possible. The demodulation schemes in this embodiment will facilitate the operation of mobile stations at lower transmission signal power levels. Receiver section 14 coherently demodulates the data received. As shown in FIGURE 1, pilot tones are inserted in the random access request packet at the mobile station, to facilitate the  
10 coherent demodulation process at the other end. The demodulated data is then decoded and checked for errors.

If a random access request packet is correctly received and demodulated, the base station 14 transmits an acknowledgment message to the mobile station 16, and schedules the user's call to proceed if appropriate channel resources are available.  
15 For short packet data (Q), the base station needs only transmit an acknowledgment message.

If no channel resources are available within the scheduling timeframe, the base station transmits a "busy" message that may instruct the mobile station when to transmit a new request. If the base station does not transmit an acknowledgment  
20 message, the mobile station can assume that the request attempt was unsuccessful.

By having a mobile station (e.g., 16, 18) transmit a random access request frame such as the frame illustrated in FIGURE 1, the required service time (K), required air time (M), and short data (Q) fields can be used advantageously to facilitate the transmission of the packet data that follows the access request. Since  
25 these fields can be predetermined and that information can be provided, a priori, to the base station's receiver, the receiver can be configured more quickly and efficiently than prior systems.

A method is also provided for regulating access request arrivals at the receiver 14 if collisions begin to occur, by having the base station broadcast an m-bit  
30 busy flag for use by the mobile stations. For example, the value of m can be determined by the number of collisions the base station has detected. The base

- 10 -

station can thus regulate the rate of the access request transmissions (and arrivals) by choosing one of  $2^m$  levels and transmitting that information for allocation purposes to the mobile stations in the network.

FIGURE 4 is a schematic block diagram that illustrates a receiver 14 that can be used to implement a method of identifying and demodulating multiple random access requests. In order to enable a base station receiver to distinguish between multiple random access requests, a novel preamble bit or symbol pattern can be used. Each requesting mobile station can transmit one of L different preamble bit or symbol patterns (hereinafter referred to as "signatures"). As shown in FIGURE 4, each of L accumulators is tuned to detect a specific signature (I) coupled from the output of the matched filter. This signature preamble arrangement (described below) may also be used for power-ramping, such as used in IS-95 and CODIT systems, to distinguish between multiple access attempts and provide separate power control processing for individual mobile stations making random access attempts.

FIGURE 5 is a diagram that shows eight exemplary signature patterns that can be used as preambles by a plurality of mobile stations. Preferably, as shown in FIGURE 5, the signature patterns used are orthogonal to each other. At the base station receiver, one accumulator is provided for each signature pattern. Each accumulator sums the signals output from the matched filter.

In operation, a mobile station (16, 18, etc.) that is preparing to transmit a random access request message, randomly selects one of the L signatures from an internal memory location. The mobile station then transmits a preamble in accordance with the selected signature's pattern. When the output of the accumulator 126 (1-I) associated with the selected signature indicates the presence of a random access signal at peak detector 128, a corresponding demodulator (not explicitly shown) is activated. A maximal ratio combining method can be used to combine all of the rays detected from that mobile station. For this embodiment, accumulator 126 is preferably a buffer memory device, wherein the matched filter output samples ( $S_{ij}$ ) are written into the rows of an array 126'. The width of the array is one symbol long (N), and the height of the array is equal to L. The array elements are added over the "accumulator window length" L. Although not

- 11 -

explicitly shown, a separate accumulator is used in each of the I and Q branches in receiver 14, so that the received signals can be coherently accumulated by a known technique. As shown by this exemplary illustration, accumulator 126 is used in the receiver's I branch. Using the structure and method illustrated by FIGURE 4, the receiver's signal-to-interference power ratio can be increased by L times over prior systems.

Specifically, the signals,  $S_{ij}$ , are multiplied by mixers 136(a-l) and summed at summer 138. The number of signatures used ( $l$ ) is preferably based on the amount of traffic on the RACH, the probability that two mobile stations will not select the same signature during the same preamble period, and the packet size constraints imposed on the RACH. In this embodiment, 8 signatures and corresponding accumulators are used, which provides a 9 dB signal gain for each mobile station's transmission. In the embodiment illustrated by FIGURE 3 above, a signature pattern (a-n) is input to a respective mixer 17a-n to facilitate the demodulation of the plurality of random access requests.

If an error occurs in demodulating the received data, a busy/flag procedure can be used. For example, the base station can acknowledge the receipt of a random access packet from a specific mobile station (that transmitted a specific signature preamble). The base station can instruct that mobile station to utilize a particular code for subsequent transmissions, and bar other mobile stations from using that allocated code. Consequently, erroneous data or unsuccessful access attempts can be detected and re-transmitted more quickly, and the probability of additional errors or collisions will be significantly reduced.

FIGURE 6 is a schematic block diagram that illustrates how multiple random access requests can be correctly received and demodulated, in accordance with a second embodiment of the present invention. The preferred method utilizes a form of multipath and space diversity reception along with selection combining techniques. Generally, diversity selection combining methods are used to individually analyze and demodulate all received rays which are above a predetermined threshold. Consequently, if a plurality of access requests arrive at receiver 114 at the same time, all of the requests will be processed equally, and the

- 12 -

probability will thereby be increased that all of the mobile stations' requests will be correctly received and demodulated.

The selection combining method utilizes both multipath diversity (e.g., demodulating multiple numbers of rays) and space diversity (e.g., multiple antennas). In this way, as shown in FIGURE 6, a plurality of access requests can be correctly received and demodulated, because the Rayleigh fading process in the transmission channel combined with the effects of these diversity reception methods can capitalize on the fact that certain access requests may be weaker than others in one diversity path, but stronger in another path.

FIGURE 7 is a schematic block diagram of the details of the base station receiver 114 shown partly in FIGURE 6, which can be used to receive and demodulate random access requests made by a plurality of mobile stations, in accordance with the second embodiment of the present invention. Receiver 114 includes a receiving antenna 122 connected to an input of a matched filter 124. During a preamble period ( $L$  symbols long), the output of matched filter 124 is accumulated in accumulator 126 over the  $L$  symbol periods to increase the received signal-to-interference power ratio. For this embodiment, accumulator 126 is preferably a buffer memory device, wherein the matched filter output samples ( $S_{ij}$ ) are written into the rows of an array 126'. The width of the array is one symbol long ( $N$ ), and the height of the array is equal to  $L$ . The array elements are added over the "accumulator window length"  $L$ . Although not explicitly shown, a separate accumulator is used in each of the I and Q branches in receiver 114, so that the received signals can be coherently accumulated by a known technique. As shown by this exemplary illustration, accumulator 126 is used in the receiver's I branch. Using the structure and method illustrated by FIGURE 7, the receiver's signal-to-interference power ratio can be increased by  $L$  times over prior systems.

The output of accumulator 126 is connected to an input of peak detection circuit 128. When a signal is detected from accumulator 126, the output of peak detection circuit 128 is coupled to a channel estimator unit 130. Channel estimator unit 130 estimates the phase and amplitude of the detected peak signal. As a plurality of signal peaks is detected from accumulator 126, the receiver assigns each

- 13 -

such signal to a separate demodulator 132a-n. Subsequently, each separate signal from demodulators 132a-n is treated as if it is incoming from a different mobile station.

The duration of a random access request transmission is relatively small. Consequently, no significant additional interference is deemed to be exerted on traffic user signals by these requests. However, the base station's receiver can use an interference cancellation unit 134 to remove any existing high interference already exerted on traffic users of the system. Interference cancellation can be readily implemented during the preamble period, because both the phase and polarity of the incoming signals are known. As the random access message data is received, the base station receiver can continue the interference cancellation process.

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

- 14 -

## WHAT IS CLAIMED IS:

1. A signal format for use in transmitting a random access request in a mobile communications system, comprising:
  - a preamble; and
  - 5 at least one of a plurality of facilitating fields, said plurality of facilitating fields including a mobile identity field, a service field, a short data field, and an air time field.
2. The signal format according to Claim 1, wherein said preamble  
10 comprises one of a plurality of signature patterns.
3. The signal format according to Claim 1, wherein said at least one of a plurality of facilitating fields comprises a forward error correction coded field.
4. The signal format according to Claim 2, wherein said one of said  
15 plurality of signature patterns is orthogonal to another.
5. A system for use in demodulating a plurality of random access request messages, comprising:
  - 20 a first plurality of matched filters; and
  - a second plurality of accumulators, an output of each of said first plurality of matched filters connected to a respective input of said second plurality of accumulators.
6. The receiver section according to Claim 5, wherein a unique signature  
25 pattern is coupled to a second input of each of said second plurality of accumulators.
7. The receiver section according to Claim 5, wherein an output of a third plurality of receiving antennas is coupled to a respective input of said first  
30 plurality of matched filters.
8. A receiver for use in demodulating a plurality of random access request messages; comprising:



-15-

a filter means for detecting at least one of said plurality of random access request messages;

an accumulator means for summing a detected said at least one of said plurality of random access request messages, said accumulator means coupled to an output of said filter means;

a peak signal detector means for detecting a predetermined signal at an output of said accumulator means;

a channel estimation means for selecting a traffic channel in response to an output signal from said peak signal detector means; and

a demodulation means for demodulating said detected at least one of said plurality of random access request messages.

9. The receiver according to Claim 8, wherein said accumulator means comprises an L by n array.

10. The receiver according to Claim 8, further comprising an I portion of an IQ demodulator.

11. The receiver according to Claim 8, further comprising the Q portion of an IQ demodulator.

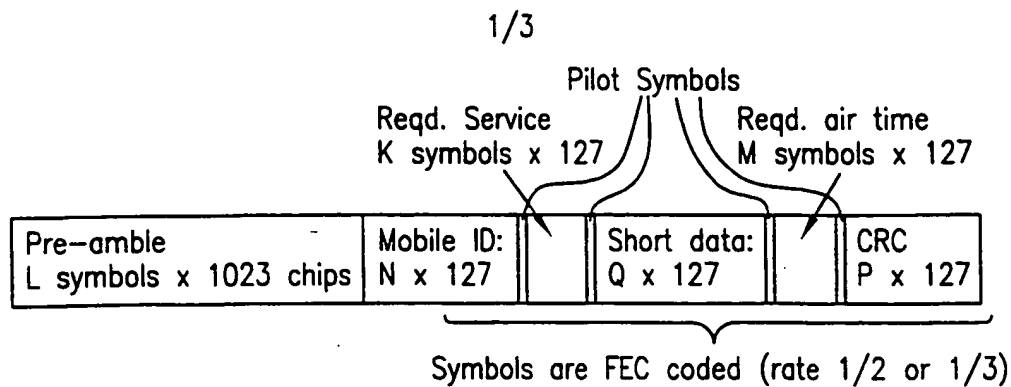
12. The receiver according to Claim 8, further comprising an interference canceller.

13. A method for controlling a transmit power level of a mobile station in a multiple random access communications system, comprising the steps of:  
detecting at least one of a plurality of random access request messages;  
accumulating a detected said at least one of said plurality of random access request messages;

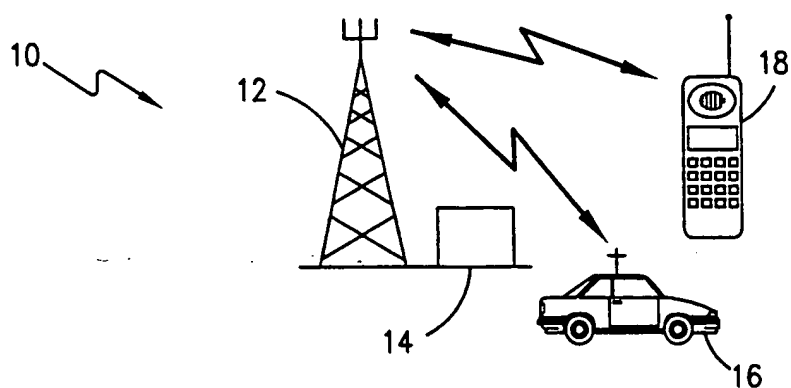
detecting a predetermined signal resulting from said accumulating step;  
selecting a traffic channel in response to said predetermined signal; and

-16-

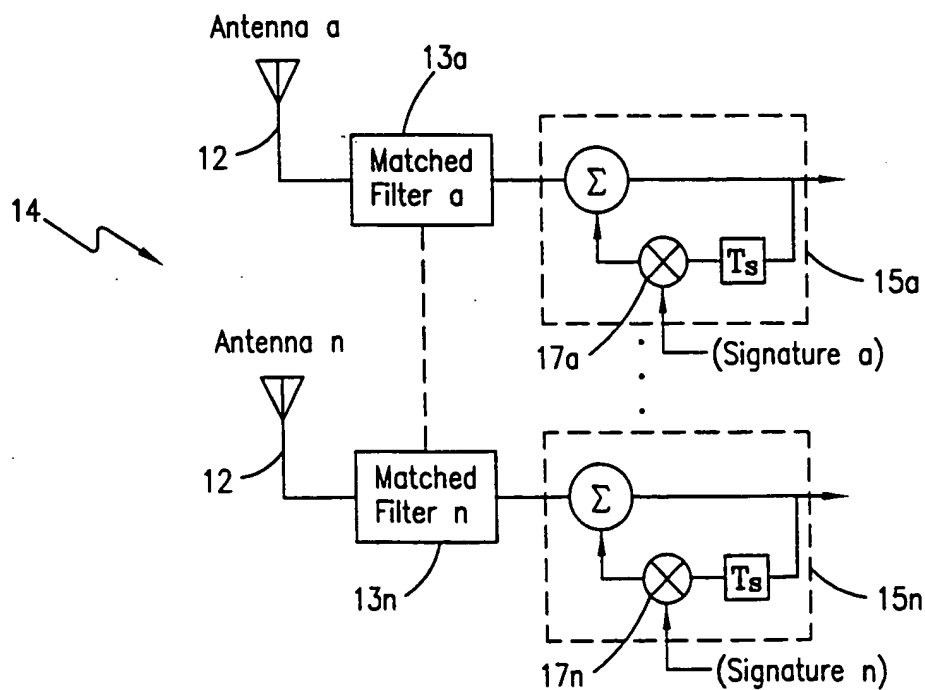
controlling a transmit power level of a mobile station associated with said at least one of said random access request messages.



**FIG. 1**



**FIG. 2**



**FIG. 3**

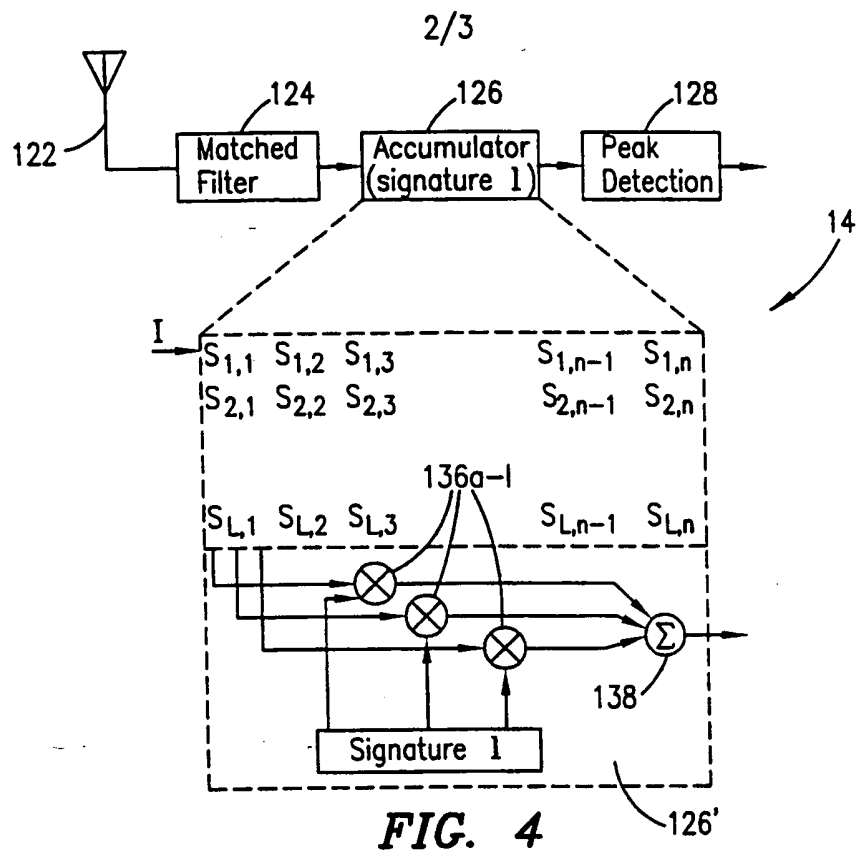


FIG. 4

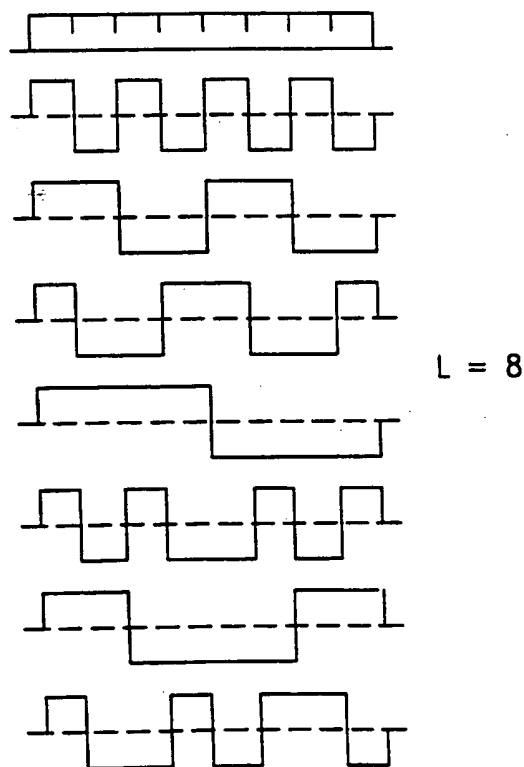
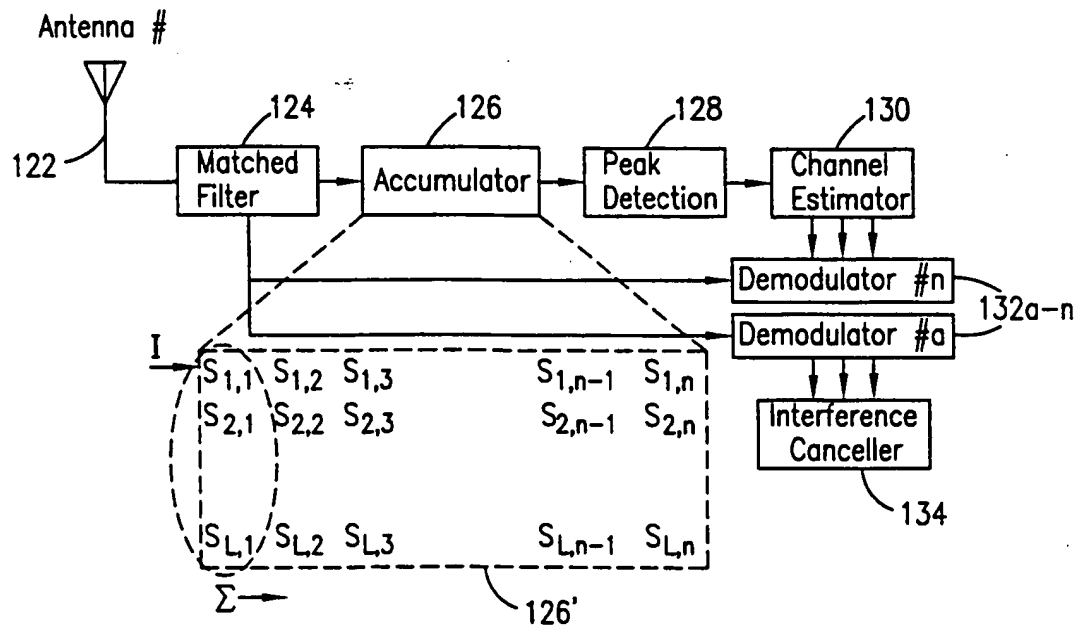
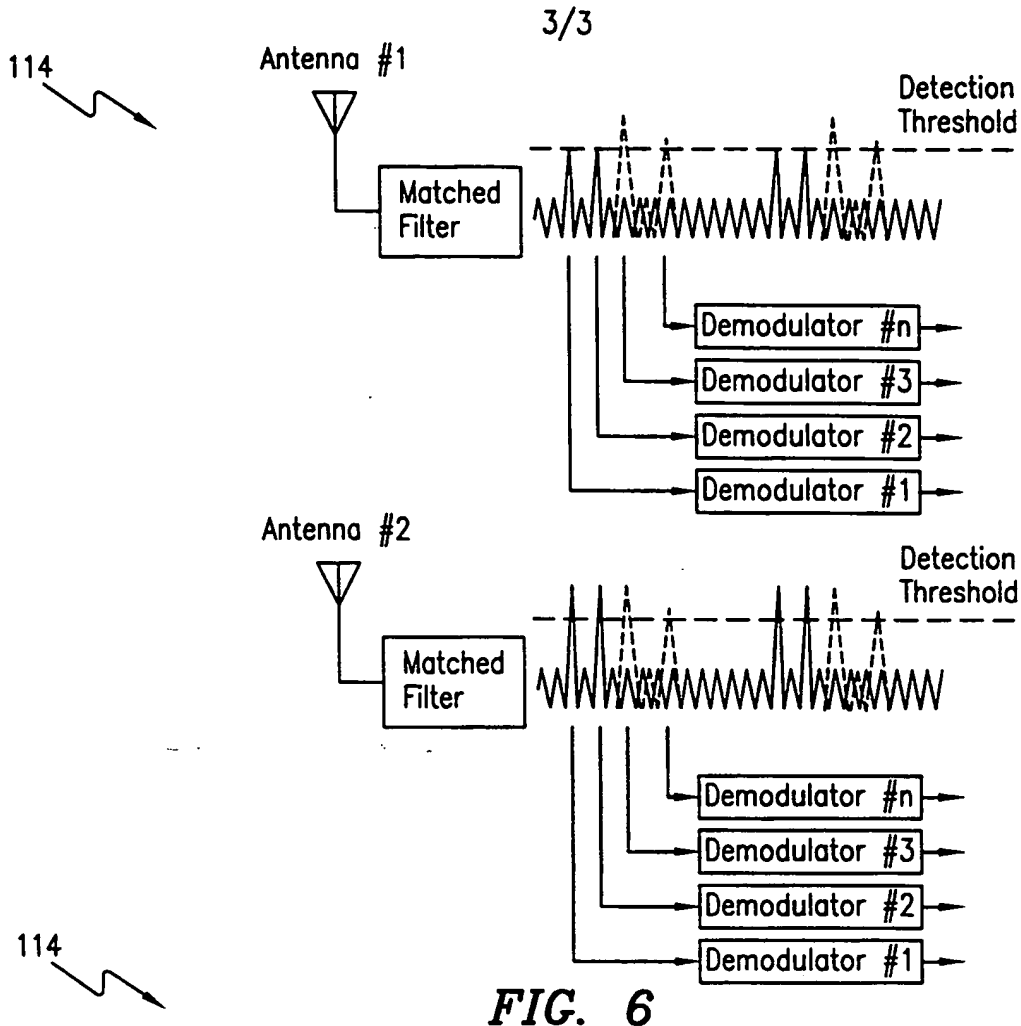


FIG. 5





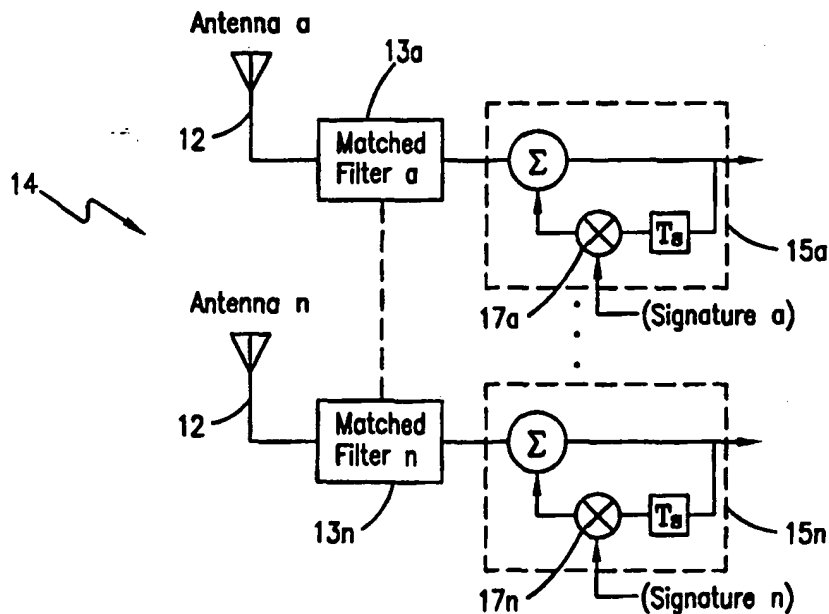


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>H04Q 7/38, 7/30, 7/32</b>	<b>A3</b>	<b>(11) International Publication Number:</b> <b>WO 98/18280</b> <b>(43) International Publication Date:</b> 30 April 1998 (30.04.98)
<b>(21) International Application Number:</b> PCT/SE97/01722 <b>(22) International Filing Date:</b> 14 October 1997 (14.10.97) <b>(30) Priority Data:</b> 08/733,501      18 October 1996 (18.10.96)      US <b>(71) Applicant:</b> TELEFONAKTIEBOLAGET LM ERICSSON (publ); [SE/SE]; S-126 25 Stockholm (SE). <b>(72) Inventor:</b> ESMAILZADEH, Riaz; c/o Agren/Nilsson, Odenatan 44, 4tr, S-113 51 Stockholm (SE). <b>(74) Agent:</b> TELEFONAKTIEBOLAGET LM ERICSSON (publ); Patent and Trademark Dept., S-126 25 Stockholm (SE).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> <b>(88) Date of publication of the international search report:</b> 16 July 1998 (16.07.98)

**(54) Title:** RANDOM ACCESS IN A MOBILE TELECOMMUNICATIONS SYSTEM**(57) Abstract**

A mobile communications system (10) is provided for significantly reducing the time required to process a random access mobile-originated call. During call setup, a mobile station (16, 18) transmits a random access packet that includes a preamble and a plurality of fields. The information provided in these fields is used by the base station (12) to facilitate a more efficient call setup and more quickly allocate channel resources. A system is also provided for detecting, identifying and receiving multiple random access requests. Each mobile station (16, 18) transmits one of a plurality of different preamble symbol patterns in a random access request packet. The base station receiver (14) includes a plurality of accumulators (126), each of which is tuned to a different preamble symbol pattern. Consequently, the base station receiver (14) can distinguish between simultaneous random access requests. This preamble symbol arrangement can also be used in conjunction with power-ramping processes, such as those used in IS-95 and CODIT systems, to provide individual power control for mobile stations making multiple random access attempts.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/SE 97/01722

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04Q7/38 H04Q7/30 H04Q7/32

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0 633 671 A (NOKIA MOBILE PHONES LTD) 11 January 1995 see abstract see column 3, line 20 - column 4, line 43 see column 4, line 55 - column 5, line 22; claims; figures see column 10, line 9 - line 55 ---	1,4-6, 8-12 2,3,7,13
A	US 5 515 379 A (CRISLER KENNETH J ET AL) 7 May 1996 see the whole document ---	1
A	WO 92 21196 A (QUALCOMM INC) 26 November 1992 see abstract see page 6, line 1 - page 14, paragraph 2 --- -/--	13



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

20 May 1998

Date of mailing of the international search report

29/05/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

Gries, T

# INTERNATIONAL SEARCH REPORT

In. ational Application No

PCT/SE 97/01722

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 25 37 683 A (LICENTIA GMBH) 3 March 1977 see claims 22,25,30,31,34; figures 1,2,5,6,10,11 ---	1-6,8-12
A	EP 0 257 110 A (STANDARD ELEKTRIK LORENZ AG) 2 March 1988 see abstract see column 1, line 18 - column 2, line 8; claims ---	1-6,8-12
A	US 5 132 985 A (HASHIMOTO TAKESHI ET AL) 21 July 1992 see abstract see column 2, line 29 - line 51 ---	1-12
A	WO 95 14336 A (NOKIA TELECOMMUNICATIONS OY ;HOTTINEN ARI (FI)) 26 May 1995 see the whole document ---	1-12
A	US 5 506 861 A (BOTTOMLEY GREGORY E) 9 April 1996 see figures 3,8,9,11 see column 2, line 16 - column 3, line 6 see column 6, line 30 - line 50; claims 1,4,5,7,10,12,17,20,23 ---	1-13
A	BAIER A ET AL: "Design study for a CDMA-based third-generation mobile radio system" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, MAY 1994, USA, vol. 12, no. 4, ISSN 0733-8716, pages 733-743, XP000588850 see the whole document -----	1-13

# INTERNATIONAL SEARCH REPORT

Information on patent family members

I. National Application No

PCT/SE 97/01722

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0633671	A	11-01-1995	JP 7059161 A	03-03-1995
			US 5577024 A	19-11-1996
US 5515379	A	07-05-1996	US 5594738 A	14-01-1997
WO 9221196	A	26-11-1992	US 5265119 A	23-11-1993
			AU 653039 B	15-09-1994
			AU 2009192 A	30-12-1992
			EP 0584241 A	02-03-1994
			FI 935105 A	17-11-1993
			HU 66044 A	28-09-1994
			JP 7500460 T	12-01-1995
			NO 934005 A	05-11-1993
			US 5485486 A	16-01-1996
DE 2537683	A	03-03-1977	NONE	
EP 0257110	A	02-03-1988	AU 591575 B	07-12-1989
			AU 7652387 A	18-02-1988
US 5132985	A	21-07-1992	JP 2051826 C	10-05-1996
			JP 4068725 A	04-03-1992
			JP 7077361 B	16-08-1995
WO 9514336	A	26-05-1995	FI 934966 A	11-05-1995
			AU 682549 B	09-10-1997
			AU 8108294 A	06-06-1995
			CN 1116476 A	07-02-1996
			EP 0692164 A	17-01-1996
			JP 8505758 T	18-06-1996
			NO 952711 A	08-09-1995
US 5506861	A	09-04-1996	AU 678618 B	05-06-1997
			AU 7893394 A	01-06-1995
			CN 1111864 A	15-11-1995
			DE 4441543 A	24-05-1995
			FR 2714243 A	23-06-1995
			GB 2284129 A,B	24-05-1995

**THIS PAGE BLANK (USPTO)**